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FOREST PEST MANAGEMENT

3430
BIOLOGICAL
EVALUATION R2-80-9

Western Tent Caterpillar

Pagosa Ranger District
San Juan National Forest

United States
Department of
Agriculture

Forest Service

Forest Pest Management
Denver, Colorado

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INTRODUCTION

The western tent caterpillar, *Malacosoma californicum* (Packard) is responsible for severe defoliation of aspen, *Populus tremuloides* Michx, on the Pagosa Ranger District in the vicinity of V-Rock Mountain and Navajo Peaks (Figure 1). This tent caterpillar outbreak was first observed in 1976. Subsequently, the outbreak was evaluated by FIDM in 1977 (J. P. Linnane, Biological Evaluation R2-77-20) and again in 1979 (J. P. Linnane, Biological Evaluation R2-79-10). At the request of the San Juan National Forest, C. K. Lister, J. P. Linnane, and B. Raimo conducted field evaluations of the outbreak during the summer of 1980.

The tent caterpillar outbreak includes approximately 16,000-17,000 acres of aspen and aspen-mixed conifer forest type. During June and July, 1980, the area was severely to completely defoliated. Observations by FIDM in late June confirmed the presence of a virus in late instar caterpillars. However, the occurrence of virus was isolated and only at lower elevations. A subsequent egg mass survey again predicts heavy defoliation (crown completely stripped) in 1981. Increment core measurements indicate approximately 50% reduction in radial growth during the last four years. Extensive tree mortality and top-killing is not apparent. Isolated top-killing is apparent in only the most severely infested stands.

BIOLOGY OF THE WESTERN TENT CATERPILLAR

The western tent caterpillar has one generation annually. In aspen stands, adult moths may be found from mid-July to early August. Adults mate shortly after emergence after which females usually deposit one egg mass on small twigs and branches in the upper crown. Embryonic development is completed within four weeks and the insect overwinters as a completely developed first stage larva within the egg. Larvae emerge in the spring about the same time as aspen bud burst. Young larvae feed gregariously and construct a silken tent within the crown, and as protection during unfavorable climatic conditions. Larvae undergo five molts and mature in 30 to 42 days. Older larvae (Figure 2) lose their gregarious behavior and wander indiscriminately on the host, adjacent vegetation, or the ground seeking additional food or pupation sites. Pupation occurs within individual silken coccoons (Figure 3). Moths emerge in 12 to 18 days.

Tent caterpillar populations probably reach epidemic proportions for a variety of reasons including favorable climatic conditions for the insect, changes in the host physiology (food quality) which improve insect vigor and fecundity, and genetic variations in insect populations invading inunfested areas. Conversely, tent caterpillar populations decline due to increased pressure from natural control agents, principally viral disease, unfavorable climatic conditions, and reduced vigor due to a decline in food (host) quality and quantity. The predictability of any of the above factors are difficult at best.

FIGURE 2. A late instar larva of the western tent caterpillar.

FIGURE 3. An aspen regeneration block defoliated by tent caterpillar.

FIGURE 1. Defoliated aspen in the Price Lakes area.

LITERATURE REVIEW OF THE TENT CATERPILLAR IMPACTS ON ASPEN

Stelzer (1968), reporting on a tent caterpillar outbreak on the Carson National Forest in New Mexico during 1961-65, found after four consecutive years of defoliation, 85-100 percent of the living aspen in some stands were top-killed. He reported 11 to 52 percent aspen mortality in the same stand.

In Minnesota, Duncan and Hodson (1958) studied the effects of forest tent caterpillar (*Malacosoma disstria* Hbn.) defoliation on aspen. They found no mortality resulting directly from defoliation or from a more intensive insect and disease attack following defoliation. The greatest loss appeared as growth reduction which was as high as 90% during the defoliation period and about 15% the following year. A second study (Churchill C.B. et al. 1964) was conducted in the same outbreak area six years after the conclusion of Duncan's and Hodson's work. This study indicated increased mortality in other than suppressed trees with increased defoliation intensity. Increased pathogen (*Fomes, Hypoxylon,* and *Nectria*), insect (principally wood borers), wind, and mechanical damage accounted for approximately 30% tree mortality in the 6-10 years following the tent caterpillar outbreak. The evidence indicated tree mortality was caused, at least indirectly, by forest tent caterpillar feeding.

Defoliation adversely impacts aspen radial and height growth. Stelzer (1968) reports a 74.6% reduction in aspen radial growth after three consecutive years of defoliation. Rose (1958), working on the effect of defoliation on radial growth of aspen in Ontario, reported the reduction in radial growth depended upon the severity of defoliation. Where complete defoliation occurred, radial growth ceased and did not resume that year despite refoliation. Lesser degrees of defoliation resulted in radial growth reduction and earlier than normal cessation of growth for the year.

EXTENT OF THE OUTBREAK

Aspen defoliation is evident in the vicinity of Buckles Lake and V-Rock Mountain and south to Navajo Peak and Price Lakes at an elevation of 8500 to 10,000 feet. The outbreak was observed from the air in June 1980. The defoliation area did not appear to differ significantly from 1979 (enclosed map) with the exception of approximately 1800 acres of scattered aspen on private lands east of the Navajo River (not illustrated).

STAND CONDITIONS

The outbreak area is predominantly aspen and aspen-mixed conifer forest types. The aspen component has been defoliated from two to four consecutive seasons since 1976. A considerable volume of aspen is in the saw-timber size class. Volumes on the best sites approach 20-25 MBF per acre. Dominant and co-dominant trees within the outbreak are 85 to 100 years old. In the Buckles Lake area, there are several four to seven year old regeneration blocks. The Price Lakes area appears to have been partially-cut in the late 1960's or early 1970's.

Stand conditions within the outbreak area vary from overmature saw-timber size trees to seedlings and saplings. The overmature aspen suffer a variety of pathological problems including; sooty bark canker (*Cenangium singulare* (Rehm.) Davids & Cash.), cytospora canker (*Cytospora chrysosperma* (Pers.) F.), ceratocystis canker (*Ceratocystis fimbriata* Ell. & Halst.) and white mottled rot (*Fomes applanatus* (Pers. ex Wallr.) Gill). Overmature stands with severe pathological problems are in a state of decline which can only by enhanced by recent defoliations.[1/] Seedling and sapling aspen suffer an estimated 60-75% reduction in height growth (1979 observations) as a result of defoliation (Figure 3). Radial growth in all size classes has been severely reduced. Top-killing is only evident in the most severely defoliated stands where approximately 5 to 10% of the trees are top-killed.

EVALUATION METHODS

Evaluation methods consist of an egg mass survey to determine the tent caterpillar population trend and increment core measurements to estimate growth loss. Tree mortality and top-killing were too scattered, at this time, to estimate effectively.

Egg mass densities are the principal tool in predicting defoliation by the western tent caterpillar. Two 30-inch branches are pruned from the upper crown of each sample tree. The average number of egg masses for the two branch sample is calculated. Egg mass densities per tree are tallied, and a mean egg mass density based on all sample trees is computed. Defoliation predictions are based on a minimum of 20 sample trees per outbreak.

In 1977 and 1978, FI&DM established eight, 1/10 acre sample plots within the outbreak area. Egg mass densities and subsequent defoliation estimates were determined for these plots in an effort to improve the accuracy of

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1/ Personal communication with David W. Johnson, Supervisory Plant Pathologist, FIDM, R-2.

defoliation predictions. In 1979 and 1980, additional trees were sampled outside the 1/10 acre plots to improve the estimate of egg mass density.

Increment core measurements are based on a single core taken at DBH from 20 dominant or co-dominant aspen. Sample trees were selected at random from five locations within the outbreak. Increment cores were prepared following Trujillo's procedure (Trujillo 1975). Measurements of the past ten years growth were made under a binocular microscope using an ocular micrometer eyepiece.

RESULTS AND DISCUSSION

A summary of egg mass sampling results for the years 1977 through 1980 is presented in Table 1. During 1977 to 1979, average egg mass densities of 2.84, 1.97, and 2.40 respectively resulted in heavy defoliation (crowns completely stripped) of aspen. The 1980 samples have an average egg mass density of 3.28. An analysis of variance of sample means and years (1977-1980) (Table 2) indicate no significant differences between years at the 0.05 level. These results predict a sufficient tent caterpillar population to again cause heavy defoliation in 1981.

Viral disease, the most effective natural control, was observed for the first time in June 1980. This disease was not widespread and from current egg mass densities (3.28) did not reduce the insect population. However, the occurrence of viral disease indicates a future tent caterpillar population decline. The extent and severity at which the disease will occur in 1981 is difficult to determine. The best assumption is to expect heavy aspen defoliation in 1981 with a significant increase in the occurrence of viral disease leading to a reduction in tent caterpillar populations by 1982.

Increment core measurements appear in Table 3. The data indicate a substantial reduction in radial increment during the years 1977-80. With the exception of 1979 and 1980, statistical tests determined all years are significantly different. Pooling the years produced very significant ($P = 0.001$) results. Comparing 1980-77 with 1976-71 and 1980-78 with 1977-71, a respective 49.9% and 56.3% reduction in radial growth occurred. The reduction in radial growth is less than experienced in New Mexico (Stelzer 1968). However the results are based on a single core sample at DBH which, at best, is only an indicator of true radial growth.

The increment core measurements also revealed a similar reduction in radial growth approximately 43-46 years ago (allowing 5 years to attain breast height). Although unconfirmed, the same stand may have been defoliated during the period 1934-47.

In summary, egg mass densities are sufficient to cause heavy defoliation in 1981. A viral disease has been observed in the caterpillar population, but its extent and severity in 1981 is unpredictable. Current damage is

TABLE 1. A summary of western tent caterpillar egg mass samplings on the Pagosa Ranger District, 1977-80.

	Year of Oviposition			
	1977	1978	1979	1980
Number of trees sampled	34	37	88	88
Total number of egg masses discovered	192	147	422	622
Average no. of egg masses per two branch sample	2.84	1.97	2.40	3.28
Standard Error	0.47	0.47	0.25	0.33
Confidence Limits	± 0.96	± 0.81	± 0.50	± 0.65
Defoliation	Heavy	Heavy	Heavy	Predicted Heavy

TABLE 2. Analysis of variance summary table for average number of egg masses per two branch sample by years.

Source of Variation	SS	DF	MS
Total	2031.77	252	
Years (77-80)	58.40	3	19.47
Error	1973.37	249	7.93

H_o: The average number of egg masses per two branch sample do not differ between years.

H_A: The average number of egg masses per two branch sample do differ between years.

$$F = 19.47/7.93 = 2.46$$

$$F_{0.05}(3, \infty) = 2.60$$

Accept the H_o

TABLE 3. Summary of increment core measurements: Mean radial increment at DBH for twenty dominant or co-dominant aspen.

Year	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971
$\bar{x}$ Radial Increment (mm)	17.4	17.4	25.1	35.4	46.1	49.8	52.0	47.7	44.6	45.0

Analysis of variance summary table for mean radial increment by years.

Source of Variation	SS	DF	MS
Total	325.06	199	
Years (80-71)	92.17	9	10.24
Error	232.89	190	1.22

H_o: Mean radial increment differs between years.

H_A: Mean radial increment does not differ between years.

$F = 10.24/1.22 = 8.39$

$F_{0.05}(9,180) = 193$

Accept the H_o

SNK Multiple Range Test indicates all years significantly different

Pooling Years to Test Differences

Test: 1980-77 vs 1976-71

$\bar{x}$ 1980-77 = 23.8 n = 4

$\bar{x}$ 1976-71 = 47.5 n = 6

t = 6.44 8 d.f.

$t_{0.001}$ = 5.04 significant

49.9% Reduction in Increment

1980-78 vs 1977-71

$\bar{x}$ 1980-78 = 20.0 n = 3

$\bar{x}$ 1977-75 = 45.8 n = 7

t = 7.34 8 d.f.

$t_{0.001}$ = 5.04 significant

56.3% Reduction in Increment

not particularly severe; 50-56% reduction radial growth, reductions in height growth, and only small amounts of top-killing and mortality in the most severely stressed trees. Observations on pathogens in the older (80-100 + yrs) and larger aspen indicate a decline in stand condition. Defoliation can only accelerate losses to pathogens. Total stand damage resulting from defoliation associated with the tent caterpillar outbreak cannot be estimated beyond what has been referenced previously.

ALTERNATIVE ACTIONS

Alternative 1 - Take no action.

This alternative allows the tent caterpillar outbreak to run its' course. Natural controls will eventually suppress the caterpillar population. It assumes damage to the aspen stand is tolerable. Total damage to the stand can be measured and recorded for future reference.

Alternative 2 - Suppress the outbreak with an aerial application of chemical insecticide.

Several chemical insecticides (carbaryl, diazinon, acephate) are registered for use against the western tent caterpillar. An aerial application of a chemical pesticide may cost $6-8 per acre. Applied properly, an insecticide application should substantially reduce defoliation without excessive environmental risk. Natural control agents, principally parasites and predators, may also be substantially reduced.

Alternative 3 - Suppress the outbreak with an aerial application of the microbial *Bacillus thuringiensis*.

Several formulations of *Bacillus thuringiensis* (B.t.) are registered for use against the western tent caterpillar. An aerial application of B.t. should substantially reduce defoliation without environmental risk. B.t. is only toxic to insects in the order Lepidoptera (butterflys and moths). An aerial application of B.t. may cost $8 to $10 per acre, slightly more than a chemical insecticide.

Alternative 4 - Assist FIDM in establishing a pilot project in the outbreak to determine losses in the aspen type as a result of the tent caterpillar epidemic and effectiveness of aerial applications of insecticides in reducing or preventing loss in aspen.

This alternative would allow establishment of several test blocks (possibly several hundred acres in size) within the outbreak. Certain blocks would be treated and others would remain untreated. Actual losses in aspen would be determined and efficacy of aerial treatments would be evaluated.

RECOMMENDATIONS

Management objectives, timber values, and aesthetic values should be evaluated for the outbreak area. If these objectives and values are determined to be in jeopardy as a result of tent caterpillar damage and if such objectives and values can justify the expense of a suppression program, we recommend Alternative 3, suppress the outbreak with an aerial application of the microbial insecticide B.t. The environmental risk of this alternative would be nearly non-existent and efficacy should be adequate for good foliage protection.

Alternative 4, assist FIDM in establishing a pilot project to evaluate insect damage and suppression strategies, may be considered should the Forest determine management objectives and values do not warrant suppression or should this alternative not unduly interfere with management objectives. The effects of defoliation on the growth and survival of aspen is not well documented in the southwest. A pilot project, as described briefly in alternative 4, would provide such information as well as determining the effectiveness of current suppression strategies in preventing these losses.

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WESTERN TENT CATERPILLAR
PAGOSA RANGER DISTRICT
1979

LEGEND

Outbreak Area

MILES